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Lockheed Martin Space Operations Shuttle Processing Contract Information Processing System (IPS)

Shuttle Processing Client/Server Shop Floor Control System

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INTRODUCTION

In 1991 Lockheed Martin Space Operations deployed a Shop Floor Control (SFC) system in all flight processing facilities at KSC.

SFC is composed of three sub-systems:

- Shop Floor Control/Data Collection (SFC/DC) - provides shop floor supervisors with an on-line capability to manage their work-in-process activities.
- Shop Floor Control/Resource Tracking (SFC/RT) - provides a real-time capability to manage and track all flight GSE.
- Shop Floor Control/Performance Analysis Reports (SFC/PAR) - provides historical and analytical reports of work-in-process delay conditions.

The system was implemented on a SPDMS mainframe computer with a character based user interface (CUI). Although workable, the character based interface proved cumbersome for the large population of new users.

An activity was initiated in 1994 to provide a more friendly mouse driven, point and click graphic user interface (GUI) on a client/server platform. The implementation approach allowed for a phased migration from the character based environment to the graphics environment by allowing updates to the same host database from both environments. The ability to phase the migration was critical because of the large number of users and the distributed nature of processing at KSC.

To differentiate it from the host based CUI system, the client/server GUI version was renamed Shop Floor Control/Work Station (SFC/WS). Phase I was completed in August 1995 with deployment in Hi-Bay 2 of the Orbiter Processing Facility. Full deployment of both SFC/DC and SFC/RT is scheduled for September, 1996. SFC/PAR is a reporting subsystem and does not require migration.

Benefits of GUI

The research firm Temple, Barkerd, Sloane, Inc. in correspondence with Microsoft and Zenith Data Systems conducted a study entitled "The Benefits of the Graphical User Interface". Their research supported seven benefits of a Graphic User Interface over a Character User Interface. The research concluded that GUI users:

- Work Faster
- Work Better
- Have Higher Productivity
- Have a Lower Frustration Level
- Have a Lower Fatigue Level
- Are Better Able to Self Teach/Explore
- Learn More Capabilities

Studies conducted by the Gartner Group and other Information Technology consulting companies have reached similar conclusions.

SFC/WS Architecture

The SFC Client/Server architecture is shown in Figure 1-1.

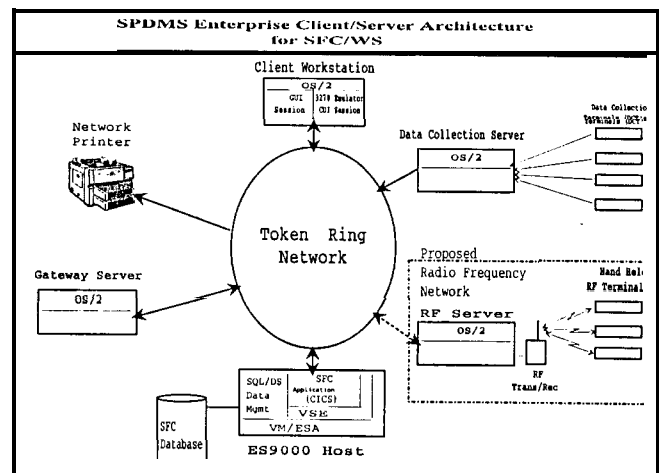


Figure 1-1. SFC Client/Server Architecture

The critical components of the architecture include:

- IBM compatible work stations
 - 386 or better
 - OS/2.2.1 Operating System
 - 12-16 Meg of memory

- Native OS/2 session
- 3270 emulation session
- Token Ring Network with Netbios and APPC protocols.
- A DDCS Gateway Server to handle Netbios/APPC protocol conversions.
- LAN Printers
- DCT - Data Collection Terminals
- DCT Servers
- Host Mainframe
 - CICS Transaction Processing Executive
 - SQL/DS Database Manager
 - SFC Database
- Proposed Radio Frequency (RF) Network
 - RF Hand Held Terminals
 - RF Transmitters/Receivers/Controllers
 - RF Servers

SFC System Interfaces

A chart showing the SFC system interfaces is shown in Figure 1-2.

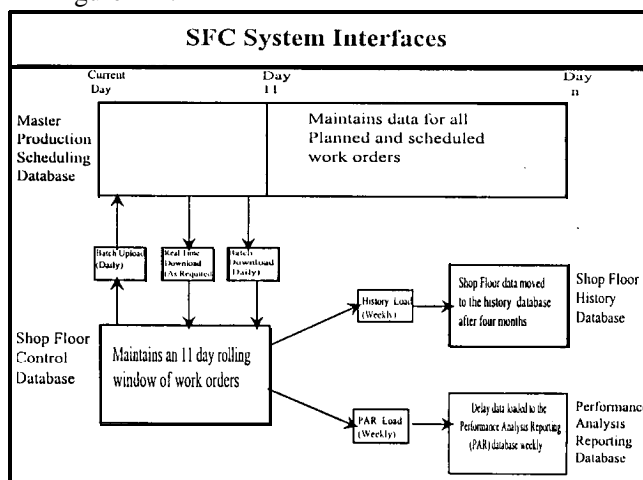


Figure 1-2. SFC System Interfaces

SFC'S primary system interface is with the Master Production Scheduling System (MPSD). MPSD is the repository for all planned and scheduled flight related work activity for Shuttle Operations. It contains large quantities of tasks covering all missions scheduled over extended time periods.

The SFC database is much more limited in scope. It only contains flight related tasks that are scheduled

to be worked within the next 11 days. A daily batch process searches the MPSD database for tasks falling within the 11 day window and loads tasks that meet the search criteria to the SFC database. If a task that is not in Shop Floor needs to be worked immediately, it can be loaded to SFC in real-time using the MPSD/SFC Real-Time Download. Another batch process is run on a daily basis that uploads completed tasks back to MPSD where they can be officially "Closed".

A weekly batch process extracts delay data for the Performance Analysis Reporting (PAR) system and removes completed tasks for update to the SFC History Database.

Delay data are tasks that were put on hold at some point during their execution cycle. The delay data is maintained at the operation level in the SFC database. This data is pulled from SFC and loaded to the Performance Analysis Reporting Database where the previous 52 weeks of delay data is maintained. Performance Analysis Reports are generated on a weekly basis and distributed to all organizations involved with Shuttle Operations.

Shop Floor tasks are maintained on the SFC database for four months. After that they are removed and loaded to the SFC History Database where the data is available for additional on-line and hard copy review and analysis.

SFC User Interface

The SFC graphic user interface provides the user with the most up-to-date techniques available with current client/server technology. It makes use of work station graphical tools including: menus, list boxes, drop-down list boxes, pop-up windows, check boxes, radio buttons, push buttons, etc. It provides for a mouse driven, point-and-click capability that allows the user to quickly navigate within a window and between windows. Using the mouse the user selects from lists of legal values eliminating data input errors; and it virtually eliminates use of the keyboard except for entry of textual data, a big plus for occasional users.

The following sections provides a description and explanation of some of the SFC windows that were developed using the graphic capabilities described above.

Shop Activity

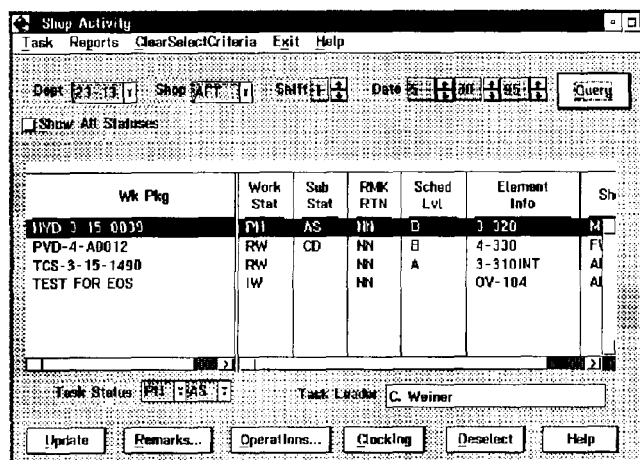


Figure 1-3. Shop Activity

The Shop Activity Window is the first window displayed after logging on to SFC/WS. It performs the following functions:

- Displays work queues for any Department, Shop, shift, and date.
- Displays all pertinent information about a task
- Allows you to delete tasks from the work queue
- Allows you to update a task's Status, Sub-Status, and Task Team Leader

The upper part of the window displays the Work Queue values. The middle section (Task List Box) displays the list of tasks comprising the work queue. The Status, Sub-status, and Task Team Leader fields display the values for the task highlighted in the Task List Box. Although only seven tasks are visible in the list box, the queue can contain any number of tasks. You can view them by using the scroll bar to navigate up and down thru the task list.

The system initially defaults to the work queue for the current date and the logged on user's department, shop, and shift. You can access another queue by changing these values and clicking the "Query" button. The system will search the Shop Floor data base for the tasks that satisfy the new criteria and display them in the Task List Box. By "double clicking" a line item in the Task List Box, the system will display the Task Detail pop-up window showing all pertinent information about that task.

Log Selection

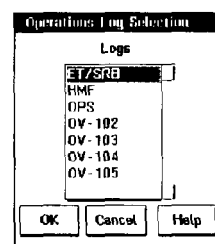


Figure 1-4. Log Selection

The Log Selection process applies to, and is only presented to Operations and Test Conductor personnel. This is a pop-up window that allows them to select the Operations Log that their remarks will be added to.

Implementation of SFC/WS, provided the capability to maintain electronic rather than hard copy Operations Logs. The dispersed nature of shuttle processing makes it difficult to maintain a common hard copy log for a vehicle. With SFC/WS, Ops Desk personnel in the processing facilities and Test Conductors in the control rooms are now able to update and review a common electronic log in real time.

The remarks are viewable on-line in the Operations Log Window and can also be printed in a hard copy report from any printer in the network.

Task Detail

Figure 1-5. Task Detail

Task detail is a query only pop-up window presented from the Shop Activity and the Available Work Windows that displays detailed information about a single task. To view the detailed task information, “double click” on the desired line item in the Shop Activity or Available Work window’s Task List box.

Operation Detail

Oper	Work Stat	Sub Stat	RMK	CR Console	Dept	Shop	Sel
10	DURING ASCENT, ME2	HO	C11	N	16-11	AFT	0
20	DURING ASCENT, ME2	RW	CD	N	FR	16-11	0
50	DURING ASCENT, ME2	RW	CD	N	FR	16-11	0
60	DURING ASCENT, ME2	HO	C11	N	FR	16-11	0
60	DURING ASCENT, ME2	HO	C11	N	FR	16-11	0

Figure 1-6. Operation Detail

The Operations Detail Window performs the following functions:

- Displays a task’s operations list
- Changes the status or sub-status of an operation
- Updates operation fields

- Adds other operations

The Operations List Box in the middle section of the window displays the operations for the task shown in the Wk Pkg Drop Down List Box. This list box contains the same list of work queue items as shown in the Shop Activity Window. Clicking on the down arrow of the Wk Pkg list box displays the work queue items. Clicking on one of these items will retrieve the operations for the corresponding task. As a quick and easy reference for the supervisor, the Work Package Number, Remark Indicator, Status Code, Sub-Status Code, and Task Number are displayed for each line item in the Wk Pkg Drop Down List Box. The fields immediately below the Operations List Box display the values of the highlighted operation. These are the only fields that can be updated from this window.

Personnel Clocking

Figure 1-7. Personnel Clocking

The Personnel Clocking Window performs the following functions:

- Displays personnel assigned to a department/shop
- Displays personnel assigned to an operation
- Clocks personnel on/off an operation

The upper part of the window displays the Wk Pkg and Operation drop down list boxes. The Wk Pkg

list box contains the same list of work queue items as shown in the Shop Activity Window. The Operation list box contains the operations of the task displayed in the Wk Pkg field.

The Personnel In List Box displays the list of personnel assigned to the department/shop/shift shown in the fields. The system defaults to the department/shop/shift of the logged on user. To display personnel in other areas, enter the desired department/shop/shift values and click on the “QUERY” button.

The Personnel Clocked On list box displays the names of personnel currently assigned to the operation shown in the Oper List Box. To clock an individual on to the job, click on his name in the Personnel In List Box and then click on the “Clock On” button. To clock an individual off a job, click on his name in the Personnel Clocked On List Box and then click on the “Clock Off” button.

- Creates Real Time Notifications (RTN’s)
- Adds, deletes Management Summary remarks

The upper part of the window displays the Wk Pkg and Operation drop down list boxes. Again, the Wk Pkg list box contains the same list of work queue items as shown in the Shop Activity Window. The Operation list box contains the operations of the tasks displayed in the Wk Pkg field.

The Log field displays the Operations Log, selected in the Shop Activity Window, that remarks will be applied to. This only applies to OPS Desk and Test Conductor personnel. The field is blank for other users.

The Rmk Type drop down list box displays the type of remark you want to add. The default is set to RMK. The other options are RTN (Real Time Notification) and RESP (Real Time Notification Response).

Real Time Notifications (RTN’s) are high priority remarks. They are used in cases when a job that is put on hold requires immediate attention. Organization(s) that need to respond are notified electronically as a RTN Actionee. Shop Floor users can view the status of RTN’s by using the Real Time Notification Query Window. (More on RTN Query Later).

The upper text box is used for entry of new remarks and update of existing remarks. The lower box displays the last three remarks (“Last 3 Remarks” radio button set on) of the current operation as the default. To view all the remarks for that operation, click on the “All Remarks” radio button.

Eligible remarks may be updated using the Update push button. Only the last remark entered may be updated and then only by the Dept/Shop that entered it. New remarks may be added by using the Add push button.

Remarks Entry

Figure 1-8. Remarks Entry

The Remarks Entry window performs the following functions:

- Queries, adds, and updates remarks

Real Time Notification

Wk Pkg	Oper NO	Curr Stat	Curr Sub Stat	RTN Act	RTN Date	RTI
S3481	HO	C11		API	01/04/96	11
S3481	HO	C11		OPS	01/04/96	11
S3481	HO	C11		GSE	01/04/96	10
S3481	HO	C11		OPS	01/04/96	10
S3481	HO	C11		LOG	01/04/96	10
S3481	HO	C11		LOG	01/04/96	09

Figure 1-9. Real Time Notification Query

As mentioned previously, high priority holds classified as Real Time Notifications (RTN's) are entered as a RTN remark. This window provides the capability to query the system for the RTN data.

The upper part of the window contains fields for the RTN selection criteria. The middle section of the window (RTN List Box) displays the RTN's that qualified for these criteria.

You can view the remarks for a specific RTN by clicking on the RTN line item and then clicking on the Remarks button. The system will display the Remarks Window with remarks for the selected RTN.

Update Status

Status	Sub	Description	Delay Cat	Delay Descri
HO	C11			
		ACTIONS ASSOCIATED	SFDC O	
		AWAITING SCHEDULING		
		WAD UNAVAILABLE		
		CONSTRAINTS UNAVAIL.		
		CONSTRAINTS INCOMPL.		

Figure 1-10. Update Status

This is a pop-up window displayed from the Remarks Entry Window after clicking on the "Oper Stat" button. The window provides a quick method of changing an operation's status/sub-status and for viewing sub-status delay descriptions.

To change the status, click on the down arrow of the Status drop down list box. The system will display the valid status codes, then click on the desired code to select it.

You can change the sub-status from either the Sub-Status drop down list box or from the Delay Description drop down list box. To change it from the Sub-Status drop down list box, click on the down arrow and then select the desired code. To change it from the Delay Description drop down list box, scroll to the desired line item and "double click" on it. The Sub-Status field will be updated with the Delay Cat value selected.

To update your selections, click on the Update push button. The system will perform the update and return you to the Remarks Entry Window.

On-Line Operations Log

Shift	Start	End	Log	Remarks
Y	01/04/96	09:19	HO C11	
K. MATTHEWS 16-11/AF				
S3481	09:17			THIS IS A TEST RSP IT SHOULD HAVE LOG AS T
N	01/04/96		HO C11	
K. MATTHEWS 16-11/AF				
S3481	09:17			THIS IS A TEST TRN WITH LOG AS THE ACTIONE
N	01/04/96		HO C11	
K. MATTHEWS 16-11/AF				
S2364	15:48			THIS SHOULD ONLY EDIT THIS REMARK.....
Y	01/03/96		RW	
K. MATTHEWS 16-11/AF				
S3481	08:24			HOLD REMARK!

Figure 1-11. On-Line Operations Log

The Operations Log is an on-line report showing the remarks entered by OPS Desk and Test Conductor personnel.

The window displays the Operations Log remarks in chronological sequence. The Log identifier is shown in the Log drop down list box in the top right. You can select another log by clicking on the down arrow, clicking on an item from the log list, and then clicking on the “Query” button.

The reporting time period is shown in the top line. The default time period is the current shift. You can select the previous 24 hour time period by clicking on the “Last 24 Hrs” Radio button. Use the spin buttons to select another time period. When selecting another time period, the date range is limited to a 7 day time span.

You can print a hard copy version of this report by clicking the “Report” button which presents you with the Report Request Window. (More on the Report Request Window later).

Available Work

The Available Work window displays a table of tasks with the following columns: Wk Pkg, Task, Shop, Work Stat, Sub Stat, SEL, and RMK. The table contains several rows of task data. Below the table are buttons for Select, Remarks..., Operations..., Exit, and Help. Above the table are filters for Dept, Shop, Shift, and Date, along with a Query button and a Show All Statuses checkbox.

Wk Pkg	Task	Shop	Work Stat	Sub Stat	SEL	RMK
HYU-3-15-0039	89215	MID	PH	QD	Y	N
STR-2-A0044	S1489	AFT	IW		N	N
S1290	S1290	AFT	RW		N	N
S3227	S3227	AFT	RW		N	N
S3228	S3228	AFT	RW		N	N
S3673	S3673	AFT	RW		N	N
S3691	S3691	AFT	RW		N	N

Figure 1-12. Available Work

The Available Work Window performs the following functions:

- Displays tasks in the SFC database
- Builds work queues

The upper part of the window displays the department, shop, shift, and date of the work queue. These

values are also used to query the database for eligible tasks. The middle section of the window (Task List Box) displays the tasks retrieved from the database. You can retrieve a different set of tasks by changing the selection criteria values in the fields in the upper part of the window or by using the Selection Criteria Window. The Selection Criteria Window has a larger more robust set of variables to use in retrieving task data. (More about the Selection Criteria Window Later.)

To add tasks to a work queue, click on the desired tasks in the Task List Box (multiple tasks can be selected at one time) and then click on the Select Push Button.

Selection Criteria

The Selection Criteria window contains several sections for filtering data. The 'Build/Display For' section includes fields for Dept, Shop, Shift, and Activity Date. The 'Display All Statuses' section has checkboxes for Shop Activity and Available Work. The 'Operations Selection Criteria' section includes fields for Dept, Shop, CR Console, and Status. The 'Task Selection Criteria' section includes fields for STS, Sub Site, Sub Facility, Sched Date, Sched Lot, and Starting Wk Pkg. At the bottom are buttons for Shop Activity, Available Work, Cancel, and Help.

Figure 1-13. Selection Criteria

The Selection Criteria window displays all data elements that can be used as database search criteria against the Shop Floor database.

The fields under the “Build/Display For” heading define the work queue fields and are loaded with the values from the previous window. The window is designed for a wide range of search criteria allowing you to retrieve anywhere from a very large set of tasks down to an individual task.

Report Request

The screenshot shows the 'Report Request' window. On the left, under 'Report Type', the following options are listed: Tie-In, Daily log, Remarks Chronology (selected), Ops Log, and Mgt Summary. Below this is a 'Selected Printers' section with a 'Printer' field containing 'HL21001J', an 'Add' button, and a 'Send to Rdrlist' checkbox. At the bottom left are 'Deselect', 'Print', 'Exit', and 'Help' buttons. On the right, the 'Available Printers' dropdown is set to '7'. Below it, the 'Tie In, Daily Log & Chronology Parameters' section includes: 'Last 24 Hours On' checkbox, 'Start Date' (11/20/1995), 'End Date' (11/20/1995), 'Shift' (1), 'Shop Dept' (23-13), 'Shop' (AFT), 'Facility' (7), 'Rmks Dept' (7), 'Rmks Shop' (7), and 'End of Shift Option' with 'No close-out' and 'Close-out tasks' radio buttons.

Figure 1-14. Tie-In, Daily Log, Remarks Chronology Report Request

The screenshot shows the 'Report Request' window. On the left, under 'Report Type', the following options are listed: Tie-In, Daily log, Remarks Chronology, Ops Log (selected), and Mgt Summary. Below this is a 'Selected Printers' section with a 'Printer' field containing 'HL21001J', an 'Add' button, and a 'Send to Rdrlist' checkbox. At the bottom left are 'Deselect', 'Print', 'Exit', and 'Help' buttons. On the right, the 'Available Printers' dropdown is set to '7'. Below it, the 'Log' dropdown is set to '1/3/95'. The 'Last 8 Hrs' radio button is selected, with 'Last 24 Hours On' and 'Data' options also visible. Below this are 'Start Date' (11/20/1995), 'Time' (13:37), 'End Date' (11/20/1995), 'Time' (13:37), and 'Shift' (1).

Figure 1-15. Operations Log, Management Summary Report Request

The Report Request window provides the ability to print five predefined hard copy reports. Report

parameters are selected from the parameters displayed in a pop-up window in the right section of the Report Request window. The system displays one set of parameters for Tie-In, Daily Log, and Remarks Chronology reports and another set for Ops Log and Mgt Summary reports. Reports are printed on the printer(s) displayed in the Selected Printers List Box. A user's default printer is initially displayed here. You can add additional printers by selecting them from the Available Printers Drop Down List Box or by using the Printer entry field.

After the print parameters are entered, press the PRINT push button to generate the report. A pop-up window with the message "Report(s) Submitted to Batch" is displayed. The report will be generated in the background and sent to the selected printer(s).

Summary

Any venture into new technology is always filled with challenges and opportunities. Migrating SFC from a host based environment to a true client/server environment was no exception. We learned a number of valuable lessons regarding:

- client/server architecture
- performance techniques
- GUI design

The most important lesson learned, however, was a reaffirmation of the need to understand how the end user does business. Only then can you design an interface that improves the process; which is, after all, the primary objective.